Development of a Multidisciplinary Optimization Software for MEMS structures, DS/MEMS

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Micro-actuators and micro-sensors that have been developed have multidisciplinary nature of operating principles or driving forces compared to usual mechanical structures. For example, a micro-gyroscope with comb type needs electrostatic force to drive it and a micro-pump is driven by a Lorentz force(electromagnetic force). In addition, some devices use a thermal bimorph effect to actuate them. To sufficiently handle a complex MEMS structure thus needs a multidisciplinary optimization(MDO) and multi-physics analysis, where the interaction between several disciplines must be considered simultaneously. Most of current design systems, however, are short of this demand. If an engineer wants to analyze and design a MEMS structure conventionally, he must do additional work of transferring data among different programs for such as structural analysis and electromagnetic field analysis. This results in much inefficiency and requires a lot of expertise.

In order to overcome this difficulty, we have been developing a software system called DS/MEMS (Design System for MEMS). DS/MEMS handles interactions among programs automatically and optimal design can be performed by using performance characteristics extracted easily from the various analysis results. DS/MEMS is based on a CAD platform and window environment which brings in much convenience and user-friendliness. It enables a user to only make a CAD model and formulate an optimal design problem in the window. However, DS/MEMS requires analysis models like finite element model or boundary element model depending on disciplines and innterfacing is a time-consuming job, although automatic mesh generation is used. Three optimization engines – nonlinear programming with finite difference method(FDM), the Taguchi method and a response surface methodology – are made available for user selection.

DS/MEMS has been tested through three MEMS structures – a micro-pump, a micro-spatial-light-modulator and a micro-mirror that are operated by electromagnetic force, electrostatic force and thermal bimorph effect, respectively. The performance of DS/MEMS and the results have been very satisfactory and the developed system is shown practicable for a multidisciplinary analysis and optimization of complex structures like MEMS.

References

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